



*The chemical division of Colas*

## **CWM® Technical Advice Document**

### **Introduction**

This document gives guidance and advice on the use of CWM-modified binders for the production of warm-mix asphalt (WMA).

CWM® is a water-free liquid additive that is used for the manufacture of WMA. By using CWM®, the production, lay down and compaction temperatures of the asphalt mix can be lowered by at least 54°F (30°C) compared to conventional hot-mix asphalt. CWM® is normally added at the rate of 0.4 % by mass of the liquid asphalt but can be added at a rate ranging from 0.2 to 0.7 %, depending on the mix being produced and the mix application.

CWM® is formulated to be compatible with all types of asphalt binders including neat, polymer modified, rubberized asphalt, and PPA modified. It can be pre-blended with the liquid asphalt at the terminal (before delivery) or dosed directly into the liquid asphalt at the asphalt mixing plant.

By the end of 2016, CWM® had been used to produce over 6 million tons of warm-mix asphalt all around the world.

### **The CWM® Technology**

CWM® is composed of a mixture of surface active agents. It works by reducing surface tension at the liquid asphalt/aggregate interface, thereby, allowing full coating of the aggregate and full compaction of the asphalt mix at the reduced mix temperatures. Consequently, CWM® can also be used as a compaction aid (without lowering the mixing temperatures) in situations where there is a long haul distance or when ambient temperatures are very low. The surface active agents present in CWM® also act to promote adhesion between the liquid asphalt and the aggregate.

The main benefits of WMA technologies are reduced fuel use and a consequent reduction in carbon emissions at the mixing plant and reduced fumes and improved working conditions for the paving crew.

Other benefits include:

- The lower mixing temperature reduces the oxidative age-hardening of the liquid asphalt during the mixing stage. This in turn increases the lifetime of the paved asphalt;
- As the laying and compaction temperatures are lower, CWM® allows a quicker return to traffic compared with conventional hot mix asphalts;
- For the same reason, multiple layers of WMA may be placed on top of one another within a short period of time.

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### Addition of CWM® into the Liquid Asphalt

CWM® can be either pre-dosed into binder at the bitumen terminal, added into the liquid asphalt storage tank at the asphalt mixing plant or can be metered directly into the asphalt binder line at the hot-mix plant.

#### Addition Rate:

CWM® is normally added to the liquid asphalt at a rate of 0.4 % by weight of total asphalt binder content. The rate can vary from 0.2 to 0.7 %, depending on the application, i.e. stiffness of the binder, temperature reduction required, haul distance, RAP & RAS content, etc. For the recommended starting dosage rate to be used at the laboratory design stage, please refer to 1 Table below.

Material Used	Typical Starting Dosage (%)
Virgin Mix	0.4
RAP 10 % or less	0.4
RAP 10 to 20 %	0.5
RAP 20 to 30 %	0.6
RAP 30 to 40 %	0.7
RAP 40 to 50 %	0.8
10 % RAP + 3 % RAS	0.5
20 % RAP + 3 % RAS	0.6
30 % RAP + 3 % RAS	0.7

**Table 1: Recommended starting dosage rate for CWM in the liquid asphalt**

**Note 1:** The above dosage rates are expressed as a percentage by weight of the virgin binder to be used in the mix. The binder present in the RAP has been taken into account by subtracting it from the target total binder content. For example, if the target total binder content of the mix is 5.5 %, then there will be 110 lb of asphalt binder per ton of mix. If 15 % RAP at 3.5 % binder content is to be used in the mix, then that RAP will contribute 10.5 lb of binder per ton of mix. Therefore, only 99.5 lb of virgin binder ( = 110 – 10.5) needs to be added per ton of mix. If the target rate of CWM® is 0.4 % (based on total binder), then **0.44 %** (which equates to  $0.4 \% \times 110 \div 99.5$ ) of CWM® will need to be added to the virgin binder at the mixing plant - to take account of the binder in the RAP. **For all WMA mixtures incorporating RAP, it is recommended to follow the instructions given in Section 6 of Appendix A of NCHRP Report 691.**

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**Note 2:** Likewise for plants using pre-dosed binder, if during mix production there is a substantial change in the amount of RAP being used (or a substantial change in the virgin binder content), the CWM® contact person should be notified to see if an adjustment needs to be made to the dosage rate for pre-blending the binder at the terminal with CWM®. It should be noted that an increase in the overall mix dosage caused by a drop in RAP content (or an increase in virgin binder content) is not detrimental to the mix performance of the CWM-modified warm-mix asphalt.

**Note 3:** While the above figures can be used as the starting dosage for mixes made using PMA and crumb rubber, higher dosages of CWM® may be required. This must be established at the laboratory design stage.

There are no special shipping requirements required for CWM-modified binder and the additive should not change the PG grade of the binder when used up to a rate of 0.4 %. However, it is recommended that prior to production that the binder is blended with the additive to verify the PG grade.

Lab studies have also shown that PPA (poly phosphoric acid) can be added up to a rate of 1.0 % without altering the effectiveness of the CWM® additive. However, it may be necessary to perform lab tests to establish that the particular PPA modified binder being used is fully compatible with CWM®.

### **Anti-stripping properties of CWM®**

CWM® also presents some anti-strip properties. When a minimum TSR value is required, additive dosage should be adapted to fulfil this requirement. If the TSR minimum requirement cannot be achieved with 0.5 % CWM®, additional standard liquid anti-strip such as TPH® can be used.

### **Blending at the Binder Terminal**

For pre-blending CWM into the binder at the terminal, equipment should include a typical injection system used to dose liquid anti-stripping additives. The pumping equipment required at an asphalt terminal facility for the introduction of CWM® into the liquid asphalt should be of a design to incorporate a prescribed rate of material and should include a pump, normally equipped with a variable frequency drive, and a flow meter (preferably a mass flow meter).

**Note 4:** When the liquid asphalt is being pre-blended with the CWM® additive at the binder terminal, additional CWM® should be added to allow for modification of the liquid asphalt that remains in the bottom of the storage tanks at the asphalt production plant. (In most cases, it will not be possible to completely empty the bitumen storage tank at the asphalt plant before the CWM-modified binder is delivered.) Consequently, for example, if 5 tonnes of liquid asphalt remains in the storage tank and the liquid asphalt delivery tanker contains 20 tonnes of fresh binder, then it should be blended with sufficient amount of CWM® to modify 25 tonnes (i.e. 5 + 20), e.g.  $25 \times 0.4 \% = 200 \text{ lb}$  of CWM.

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**Note 5:** If the amount of additive in the binder is inferior to what it should be because of a new mix formula (for example: the pre-blended binder has been ordered for a job without RAP and the asphalt producer wants to use the remaining binder in the tank with RAP), some additive can be added into the tank at the plant to raise the dosage to what it should be (allowing 2 hours of recirculation or agitation to homogenize the new mixture). Alternatively, the pre-blended binder can be used as it is but with an intermediate mix temperature between standard hot- and warm-mix asphalt.

Once delivered, there are no special equipment or calibration requirements at the HMA facility. Storage and handling procedures for the PG binder dosed with CWM® are the same as those that apply to the base PG Binder. When the CWM-modified liquid asphalt is stored at typical temperatures of 290 to 340 °F, field experience and laboratory studies indicate no loss of CWM®'s effectiveness after up to 10 days of storage. However, the storage stability of the additive in the hot-binder depends on the nature of the asphalt binder. If the CWM-modified liquid asphalt is to be stored hot for more than 7 days, it is recommended that a thermal stability test is performed with the binder intended to be used in the project. Based on the aforementioned thermal stability test results, or if the binder is stored hot more than 10 days, it is recommended to lower the storage tank temperature and re-heat the material when it is ready to be used. Mixing or recirculation of CWM-modified liquid asphalt are good plant practices but not necessary as CWM® will not separate from the binder during storage.

#### **Direct in-line dosing of CWM® at the Hot Mix Plant**

If the CWM® additive is not pre-blended into the liquid asphalt on arrival at the hot-mix plant, then it can be added directly in-line into the required PG binder as required. Equipment should include a typical injection system used to dose liquid anti-stripping additives. In-line injection is the most convenient way to get the additive into the binder when the plant operator wants to be able to switch easily from HMA to WMA and vice versa. It also means that the CWM® is only used when needed and at the desired dosage rate. There is no difference if it is a batch plant or a drum plant because the additive is introduced in the liquid asphalt prior to the mixing step.

#### **WMA production temperatures:**

When CWM® is used, it is generally recommended to start with a mixing temperature that is 30 °F lower than an equivalent hot-mix temperature for short haul distances. Once compaction is achieved in the field to the required densities, one can further lower mix temperature; as long as the desired densities are achieved in the field. Previous experience has shown that the mixing temperature can be reduced by about 40 to 60 °F with CWM®.

For longer hauls it is important to focus on the temperature behind the screed and aim for a 30 °F temperature reduction behind the screed. Once compaction is achieved, a further reduction in mix temperature can be tried, as long as compaction is still achieved.

In cases where the CWM® additive is being used as a compaction aid and anti-strip for hot-mix asphalt, normal hot-mix temperatures are recommended (typically with very high RAP containing mixes, or in early/late season cold weather paving or long haul paving). The target production temperature must be adjusted to assist the contractor in achieving the required field compaction.

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### **On-Site Compaction Temperature:**

Typical initial field compaction should be 40 to 60 °F less than the recommended compaction temperature for HMA. The minimum and maximum compaction temperatures would be determined by conditions required to attain required field densities.

All production, hauling, lay-down and compaction procedures that are followed for standard HMA should be followed. The only difference is the 40 to 60 °F reduction in mix temperature. The pavement can be opened to traffic or overlaid when the pavement reaches 140 °F or less or as required by current state specifications.

It should be noted that WMA is always a bit stiffer for handwork than HMA. If a lot of handwork is forecast on a project, it is recommended to use a mixing temperature 10 °F higher than is used for a standard paver job with WMA.

### **Mix Design and QC Testing of CWM-modified Warm-mix Asphalt:**

Mix design and QC/QA testing procedures for CWM-modified WMA are the same as those used for regular HMA and as advised in NCHRP Reports 691, 763 and 817, respectively. Only mixing temperature and compaction temperature are different and should be representative of real operating temperatures. A temperature drop of 20 °F from the mixing temperature should be considered for setting compaction temperature for laboratory specimens. It is recommended that the warm-mix specimens are conditioned at 275 °F for four hours before compaction for lab performance tests.

### **Shipping:**

CWM® is available in 55 gallon drums and 2,100 lb totes and also in bulk.

### **Handling:**

Like most of the chemicals used in paving industry, CWM® is a hazardous material and must be handled cautiously with all adequate safety equipment (gloves, goggles, long sleeves, etc.) to avoid chemical burns in case of contact. For further information, consult the Material Safety Data Sheet (see attached MSDS). When added to the liquid asphalt at the recommended dosage levels, this product does not change the binder classification regarding health and safety regulations.

### **Storage:**

CWM® may be stored in carbon steel tanks. Bulk stores should be maintained at 10 to 30 °C (50 to 86 °F). It is better to avoid submitting CWM® to very low temperatures (below -10 °C or -14 °F), as it can cause partial crystallization. If it happens, product would just need to be heated and homogenized before being used.

### **Shelf Life:**

When the CWM® totes are stored properly they have an indefinite shelf life. However, it is recommended that every 4 years a sample is taken, analyzed and the product recertified.

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